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ABSTRACT

The study sought to use Jensen's two-level theory of mental abilities to predict some hitherto unknown or unnoticed phenomena--facts about which the theory should yield clear-cut predictions and which are not as clearly predictable from other theories, though they may receive ad hoc explanations after the fact. From the two-level theory of mental abilities (Level 1: rate learning and memory, involving little or no transformation of the input; Level 2: complex cognitive processing involving transformation and mental manipulation of input) it was predicted that forward digit span (FDS) should correlate less with IQ than backward digit span (BDS), and age and race should interact with FDS-BDS, with the FDS-BDS difference decreasing as a function of age and a greater white-black difference in BDS than in FDS. The latter prediction is derived from the hypothesis that the magnitude of racial differences should be a function of the degree to which Level 2 predominates in the cognitive demands of the particular test. The predictions were substantiated at a high level of significance in large representative samples of white and black children of ages 5-12 years, who were given the Wechsler Intelligence Scale for Children (Revised). Supplementary studies found no support for rival hypotheses based on anxiety, task difficulty, and race of examiner. (Author/JM)

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Forward and Backward Digit Span Interaction With Race and IQ: Predictions from Jensen's Theory

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ABSTRACT

From Jensen's two-level theory of mental abilities (Level I: rote learning and memory, involving little or no transformation of the input; Level II: complex cognitive processing involving transformation and mental manipulation of input) it was predicted that forward digit span (FDS) should correlate less with IQ than backward digit span (BDS), and age and race should interact with FDS-BDS, with the FDS-BDS difference decreasing as a function of age and a greater White-Black difference in BDS than in FDS. The predictions were substantiated at a high level of significance in large representative samples of White and Black children of ages 5 to 12 years, who were given the Wechsler Intelligence Scale for Children (Revised). Supplementary studies found no support for rival hypotheses based on anxiety, task difficulty, and race of examiner.

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Forward and Backward Digit Span Interaction with Race and IQ: Predictions from Jensen's Theory[1]

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A philosopher of science, the late Imre Lakatos (1970), built his theory of scientific progress on the central idea that the chief criterion for appraising the progressiveness of theories or research programs is whether they can predict novel facts, as contrasted with merely concocting ad hoc interpretations of already established facts. If the predictions seem unlikely or defy common sense expectations, so much the better for the theory if they are borne out, so much the better for the theory.

In an attempt to apply this criterion to Jensen's two-level theory of mental abilities, we have sought to use the theory to predict some hitherto unknown or unnoticed phenomena--facts about which the theory should yield clear-cut predictions and which are not so clearly predictable from other theories, though they may receive ad hoc explanations after the fact. Whether the predicted facts themselves are of any immediate or practical consequence is irrelevant in this context. The aim is only to test the theory.

The original formulation of the two-level theory stated: "Level I involves the mental registration and consolidation of stimulus inputs and the formation of associations. There is relatively little transformation of the input, so there is a high correspondence between the form of the stimulus input and the form of the response output. . . . Level II abilities, on the other hand, involve

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Insert Figure 2.3 about here

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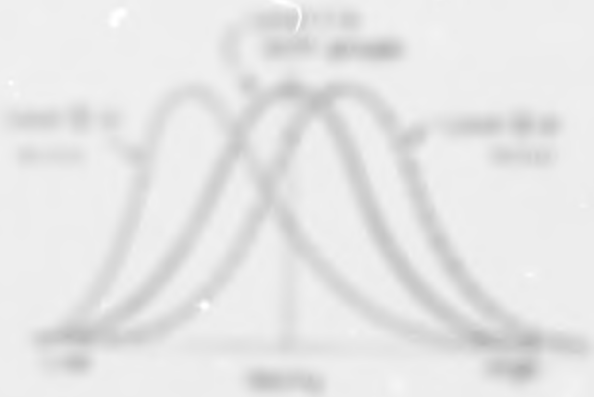

Fig. 6. Hypothetical distributions of small (‘normal brain’) and large (‘cerebral brain’) archives in Mice and Rats populations.

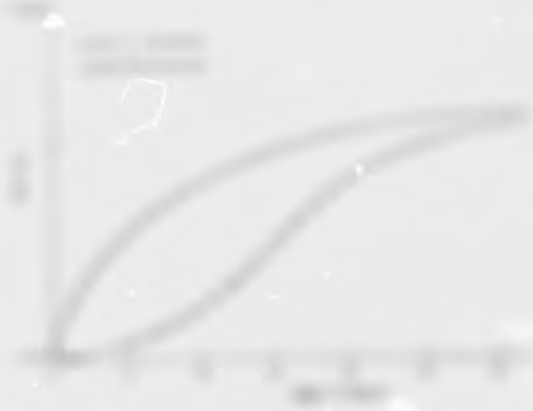

Fig. 8. Hypothetical growth curves for small (‘rat-brain’) and large (‘M. musculus’) archives.

Table 2

Means, Standard Deviations, and Sigma (σ) Differences[1] Between Whites and Blacks on Digit Span and IQ

	Forward DS		Backward DS		Verbal IQ		Performance IQ		Full Scale IQ	
Race[2]	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
White	10.75	3.01	11.01	2.99	102.13	14.44	103.99	13.64	103.24	13.79
Black	9.98	3.01	9.32	2.97	88.00	13.58	89.63	13.58	87.77	13.07
σ Difference	0.25		0.57		1.01		1.05		1.15	

[1]Scaled Scores, $\bar{X} = 10$, $\sigma = 3$.

[2]White $N = 669$, Black $N = 621$.

significant (F = 8.38, df = 1, 1276, $p < .001$).

Hypothesis 3 states that forward and backward digit span interact with chronological age in such a way that the difference between BDS and FDS decreases with age. This prediction is substantiated. The mean raw score differences of BDS-FDS over seven age groups in one-year intervals from age 5-0 to 11-12 are: 2.71, 2.48, 1.84, 2.14, 2.08, 1.94, 1.77. The ANOVA shows a highly significant decreasing linear trend (F = 4.04, df = 6, 1276, $p < .001$). The overall Race × Age interaction is nonsignificant ($F < 1$), i.e., the races are roughly parallel in the growth curves of total digit span. The triple interaction of Race × Age × FDS vs. BDS, however, is significant (F = 2.22, df = 6, 1276, $p < .05$), and reflects the Blacks' relatively lesser convergence of forward and backward digit span with increasing age.

Supplementary Studies

Anxiety Hypothesis. A possible rival hypothesis is that the observed effects are the result of greater anxiety or distractability in the Black children, which could differentially interfere with performance on forward and backward digit span. If (a) BDS is more adversely affected by anxiety than FDS, and (b) if IQ test performance is also hindered by anxiety, and (c) if Blacks are generally more anxious than Whites, then we should predict that (a) Whites exceed Blacks in total digit span, (b) Blacks are relatively lower in BDS, and (c) Blacks show a higher correlation than Whites between digit span and IQ and a relatively higher correlation for BDS than for FDS. This is what was found. The interaction of Age × FDS vs. BDS can be predicted from the anxiety hypothesis if we make the additional assumption that anxiety decreases between ages five and twelve.

So how are we to decide between the Level I-II theory and the anxiety theory in interpreting these results?

It has been reported frequently in the clinical literature that anxiety has a greater adverse effect on digit span than on any of the other subtests of the Wechsler (e.g., Payne, 1961, p. 233). In fact, a low digit span score, relative to the other Wechsler subscales, is generally interpreted as an anxiety indicator. This being the case, if Blacks were more anxious than Whites one should expect Blacks' performance on digit span to be among their lowest scores, whereas in fact they do better on digit span than on any of the other subtests which are less affected by anxiety.

Are Blacks in general more anxious than Whites? In a large sample of school children in grades 4 to 8 Jensen (1973d) found a small but significant White-Black difference in the N scale of the Junior Eysenck Personality Inventory, which is an anxiety scale similar to and highly correlated with Taylor's Manifest Anxiety Scale. But the Whites had the slightly higher score (less than 1 point). Moreover, the N scale showed nonsignificant and negligible correlations with verbal and nonverbal IQ in both racial groups. But a review of research on the relationship between anxiety and performance on the Wechsler scales found little consistent evidence of a relationship between digit span and the kind of trait anxiety measured by questionnaires; however, the literature shows quite consistently that digit span performance is related to state anxiety (Matarazzo, 1972, pp. 445-6). "State anxiety" (also called "situational anxiety") is anxiety aroused in a specific situation, as contrasted with a more or less chronic disposition (called "trait anxiety"). If this is the case, the anxiety hypothesis cannot be properly tested by using a self-report inventory of trait anxiety. There is another possible drawback to scores on a personality inventory: they can be adventitiously correlated with IQ without there being

any direct causal connection between the personality trait and intelligence test performance. For example there is a significant negative correlation between IQ and the Lie scale of the Eysenck Personality Inventory (Jensen, 1973d); and Gough (1953) has devised a "nonintellectual intelligence test" wholely out of personality inventory items which correlate with IQ without any implication that changing the personality traits involved would alter the IQ.

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The only satisfactory recourse is to rely on the construct validity of state anxiety and devising a test situation in which the effects of state anxiety should be manifested and then see if the predicted effects are borne out. This is the approach. Reviews of the literature on the effects of state anxiety on test performance (e.g., Matarazzo, 1972, pp. 443-8) suggest that it operates through such mechanisms as emotionality, excitability, inattentiveness, and distractability. The anxious subject's emotions interfere with his giving his full attention to the immediate required task, and his efficiency is thereby reduced. State anxiety therefore especially affects timed tests in which the efficiency of the subjects' mental activity in utilizing the time available is an important aspect of performance.

Our aim, then, should be to administer the very same level I test, such as forward digit span, under two different conditions, one of which should magnify the interfering effect of state anxiety. In a previous study (Jensen, 1965) it was found that any enforced delay in the recall of a series of digits resulted in fewer digits being recalled than if recall immediately followed the presentation of the digit series; this was true only if a distracting stimulus was interposed during the delay interval between presentation and recall. Without interposed distraction, subjects use the delay interval for rehearsal and consolidation of the presented material, and this improves recall. Under nondistracting delay in recall, provided the delay is not too long, the short-term

memory trace is protected to some degree from "output interference," i.e., the loss of the latter part of the digit series as a result of having to recall the first part.

Since state anxiety is manifested as distractability in the test situation, it should act as an interfering event to the recall trace, and consequently one should predict that the digit span performance of more anxious subjects should benefit less from delayed recall (as compared with immediate recall) than the performance of less anxious subjects. The hypothesis that Blacks are more anxious than Whites thus yields the prediction that the White-Black difference in digit recall should be greater under the condition of delayed recall than under immediate recall.

This prediction was tested on large random samples of White and Black children in two California school districts, Bakersfield and Berkeley, hereafter called Districts A and B. The data from the two districts can be viewed as independent replications of the experiment. District A provided a total of 1,892 White and 1,470 Black 3s about equally apportioned in Grades 3 through 6. District B provided a total of 2,681 White and 2,134 Black 3s about equally apportioned in Grades 2 through 6.

A group-administered FDS test, given by means of a tape recording to insure uniformity of pacing, etc., presented digit series of 4 to 9 digits. 3s wrote their responses on specially prepared answer sheets. Each digit recalled in the correct position is scored 1 point. Thus the highest possible score on the test is (4 + 5 + . . . + 9 = 39.) Both the immediate (I) and the delayed (D) recall tests were preceded by three practice series of 3 digits each. Every 3 received both I and D conditions. A "bong" signaled the beginning of every series and also the time for recall. In the immediate recall condition the "bong" always came 1 second after the last digit in the series. In the delayed recall condition the "bong" came 11 seconds after the last digit. 3s were

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